Charged Hadron Suppression at High p_T in AuAu Collisions at 200 GeV

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Motivation

The suppression of single hadrons still provides one of the strongest constraints on energy loss mechanisms in the Quark-Gluon Plasma. At RHIC, neutral pions have provided the best measurement of single particle suppression to date. Charged hadrons have independent sources of systematic uncertainty and can thus provide additional constraints. At PHENIX, the measurement of charged hadrons has been limited to $p_T < 10$ GeV/c by off-vertex background from photon conversions and weak decays mimicking high p_T particles. The silicon vertex tracker upgrade (VTX) is used to reject this background allowing the measurement of the charged hadron spectrum out to a significantly higher momentum.

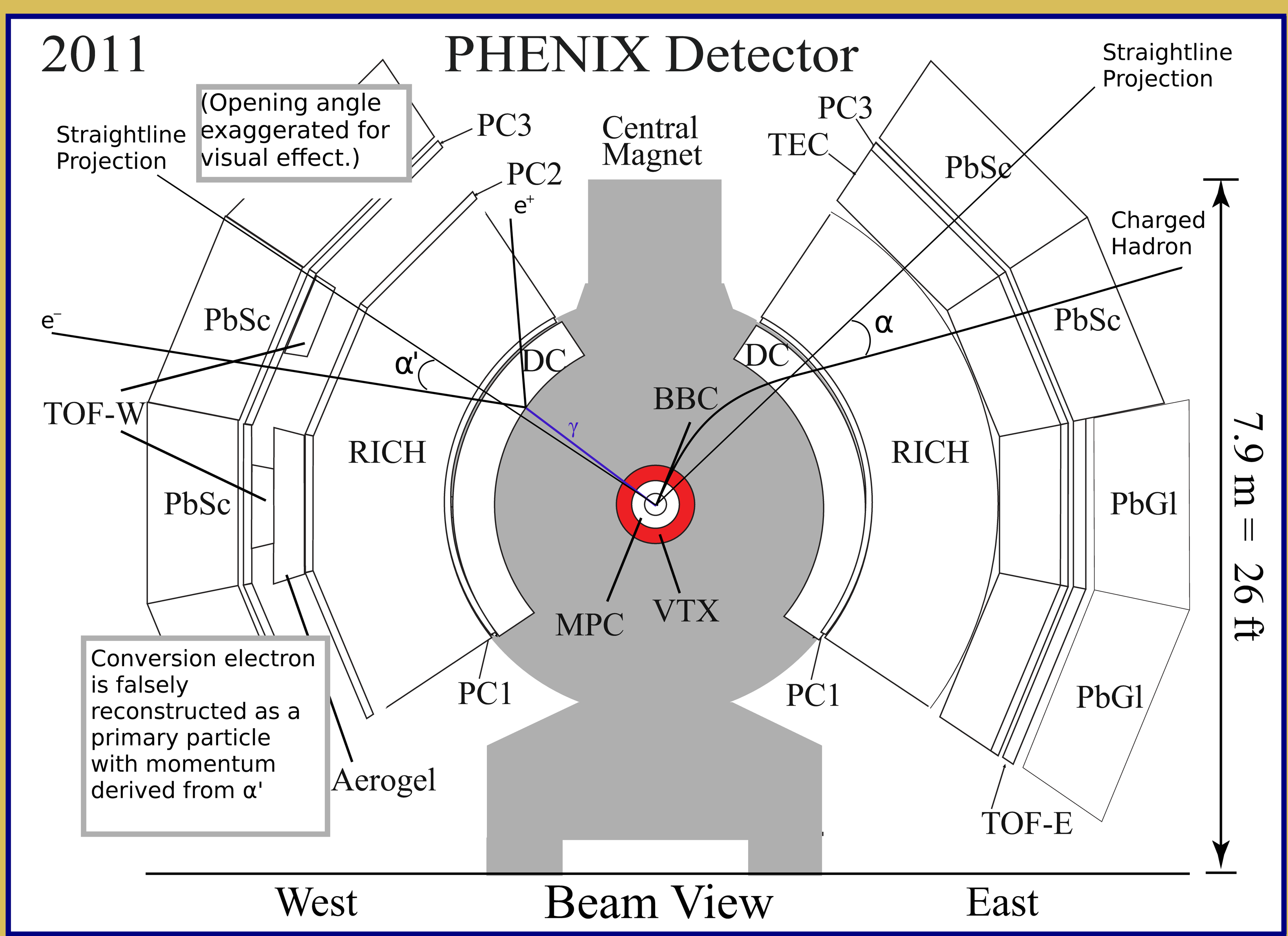

Figure 1: The PHENIX detector as configured in 2011. A signal particle is pictured on the right. The drift chamber measures momentum by calculating the difference in angle between a particle's track and a straightline projection to the collision vertex α. As seen on the left the angle α' calculated for conversion or a secondary particle may result in a different momentum than its parent particle.

Background Limitations

- Conversions and weak decay products can mimic high p_T particles
- Since momentum is calculated by projecting tracks from the drift chamber back to the collision vertex, it will be miscalculated for tracks not originating from the vertex
- For example, a photon originating from an heavy ion collision could convert into an e^+e^- pair on the entrance window of the drift chamber (Fig. 1)
- Weakly decaying particles may also decay before reaching the drift chamber and be assigned an incorrect momentum
- These background tracks can be rejected by the silicon vertex tracking detector

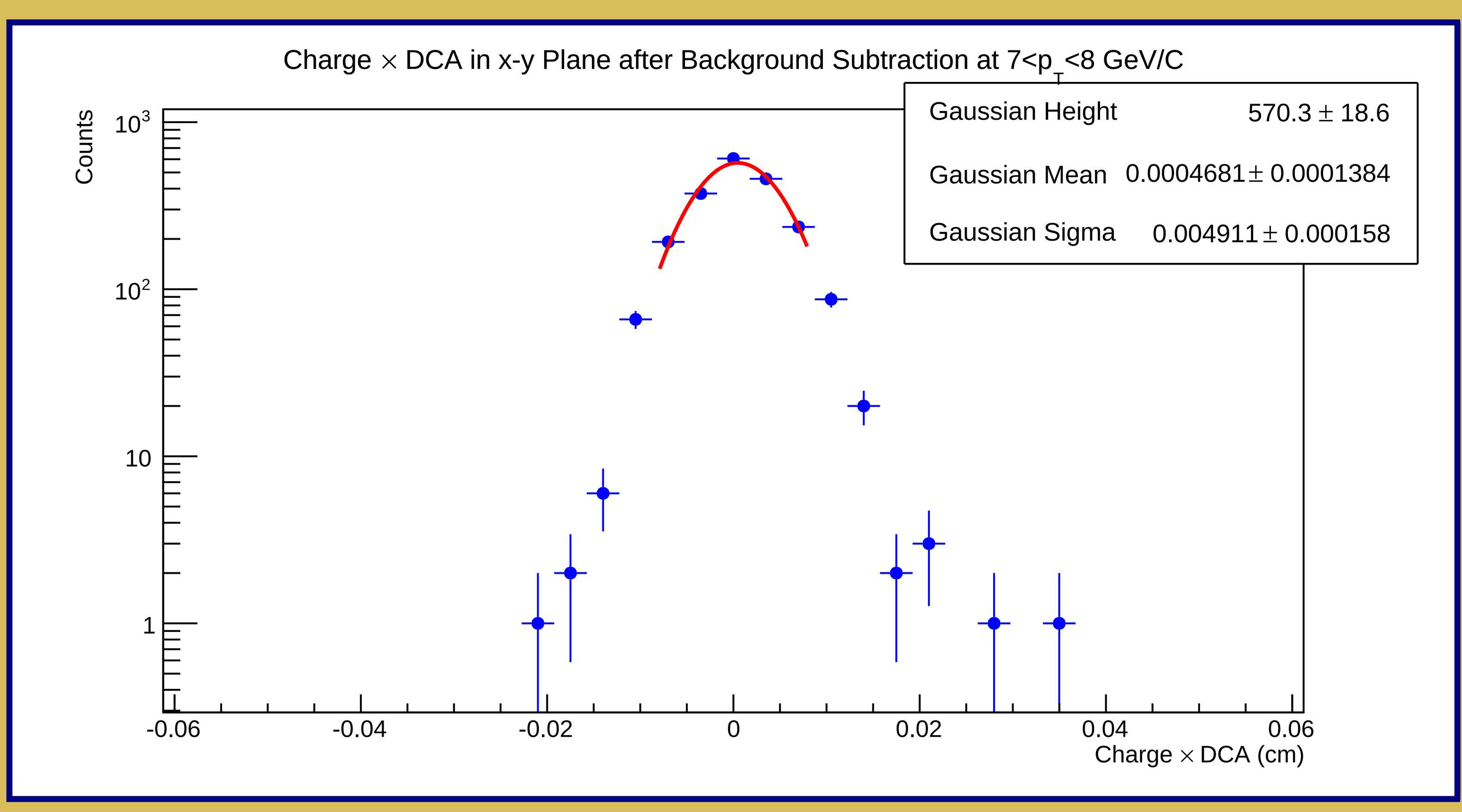

Figure 2: Charge $\times$ Distance of closest approach (DCA) in the transverse plane after tracks with a large DCA in the longitudinal direction have been subtracted for $7 < p_T < 8$ GeV/c. Final DCA is fit to a Gaussian and integrated over $\pm$ 2 sigma.

The silicon vertex tracker (VTX)

- Consists of four layers of micropattern silicon tracking detectors close to the beam pipe
- Provides precision tracking near the collision vertex
- Drift chamber tracks are matched to hits in the VTX
- Much of the background from conversions and weak decays can be rejected by requiring that tracks have 4 associated hits in the VTX
- Further background can be rejected by requiring a small distance of closest approach (DCA)
- DCA is calculated by projecting a track back to the collision vertex and measuring the smallest distance between the vertex and the track
- Real particles originating from the collision are expected to have Gaussian distributed DCA centered around the origin with a sigma of approximately the VTX resolution of $\backsim 70$ microns

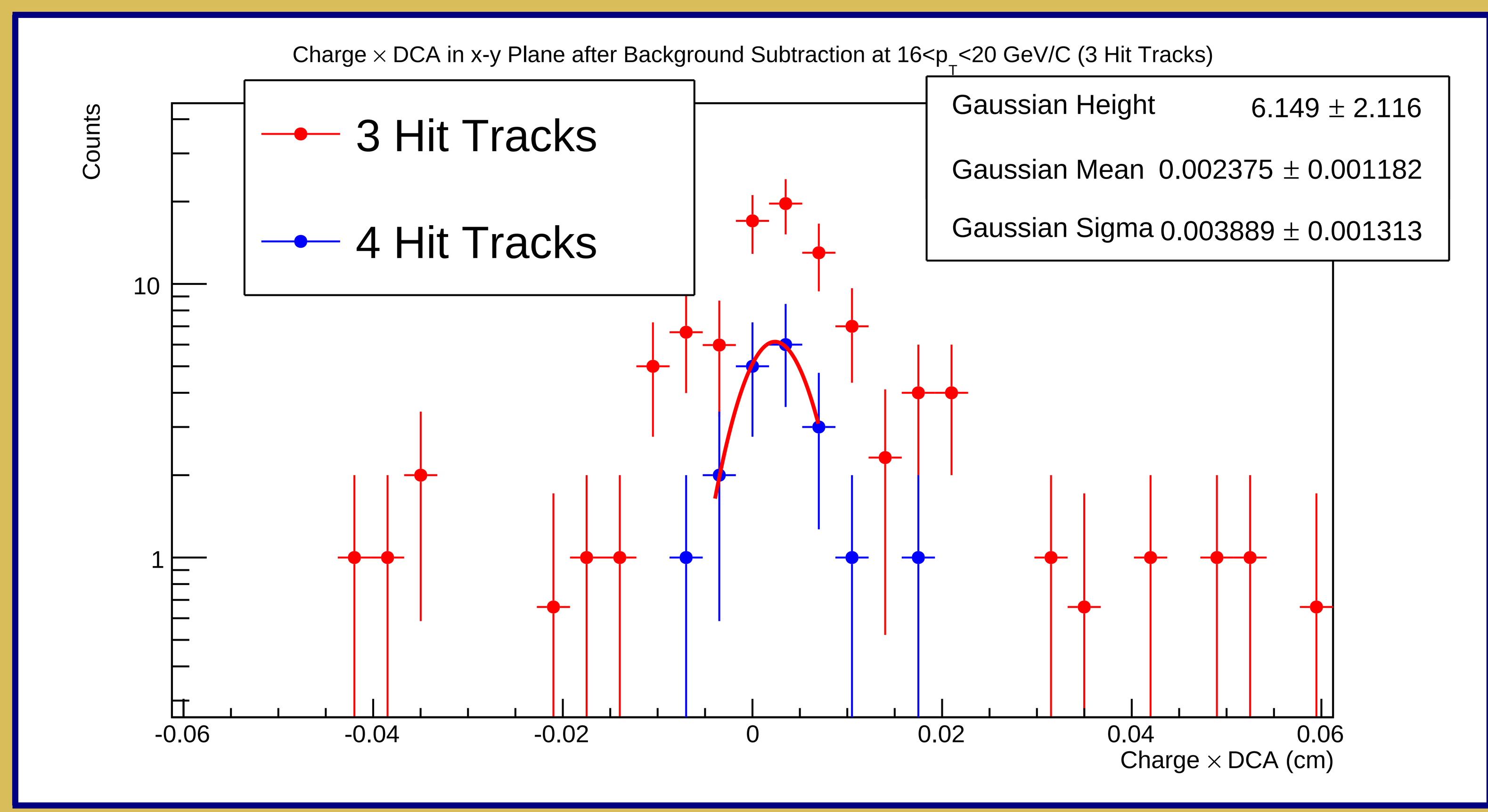

Figure 3: Charge $\times$ Distance of closest approach (DCA) in the transverse plane after tracks with a large DCA in the longitudinal direction have been subtracted for $16 < p_T < 20$ GeV/c.

A Priori Background Estimate

- The amount of background remaining after associating with VTX hits and cutting on DCA can be estimated a priori by taking in to account the effects of occupancy and multiple scattering on the tracking algorithim
- The probability of associating an off-vertex drift chamber track with random hits or random tracks in the VTX is very small compared to the number of real tracks

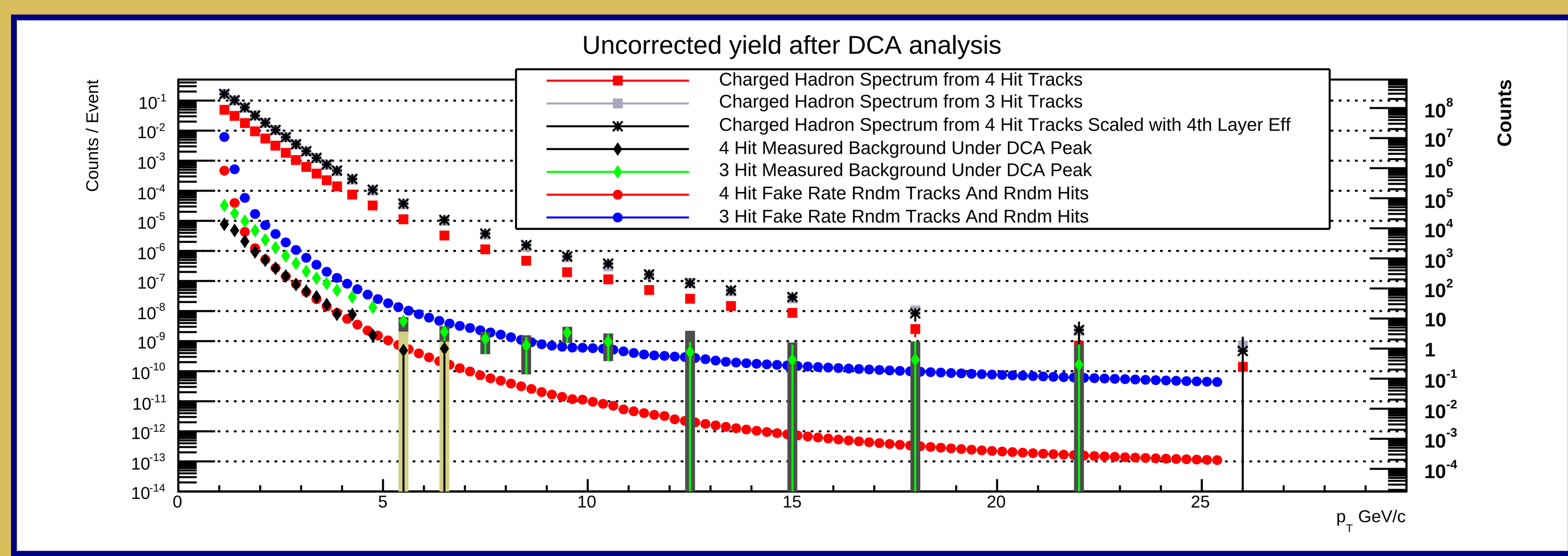

Figure 4: Comparison of measured signal and estimated background rates for tracks with both 3 and 4 hits in the VTX.

p_T Spectrum

- The uncorrected p_T spectrum is calculated by integrating the Gaussian peaks of the DCA distributions in each p_T bin
- Background tracks are expected to have a randomly distributed or flat measured p_T distribution
- Without matching in the VTX, the flat background spectrum seems to dominate after 6 GeV/c (Blue curve in figure 5)
- The spectrum of real tracks matched to the VTX extends to > 20 GeV/c

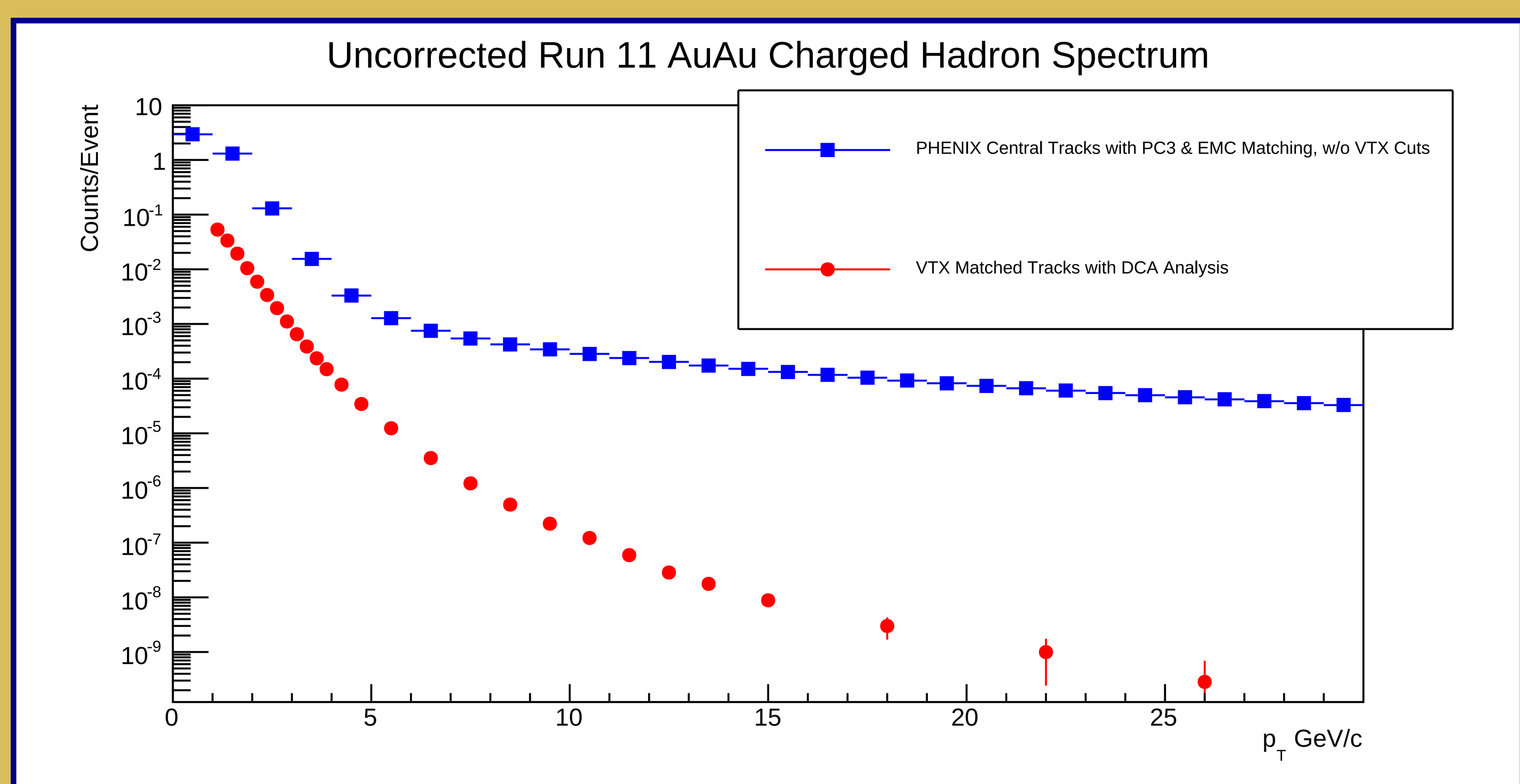

Figure 5: Uncorrected Run-11 AuAu p_T Spectra. The spectrum obtained without matching to the VTX is shown in blue. In red, the spectrum of tracks with associated hits in the VTX and with a low DCA is shown.

Conclusions

Most of the background limiting the measurement of charged hadrons in PHENIX is from tracks which do not originate from the collision vertex. Using the VTX detector we can eliminate much of this background. Estimating the number of remaining background particles which do not originate from the collision vertex, but are still accidentally matched to hits in the VTX indicates that the number of such particles is very low compared to the signal.